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## Kapok.

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This investigation was undertaken with a view to obtaining analytical data which could be used as criteria for comparing samples of kapok.

The kapok examined was obtained from the following sources:—

*A. & B.*—From a supply obtained by the Chief Field Officer in 1925 from Malay Kampongs situated along the Perak River.

*C.*—From trees growing at the Government Experimental Plantation, Serdang, which were roughly four years old at the time of harvesting in 1926.

Some samples obtained by the Agricultural Economist from the Department of Landbouw, Nijverheid en Handel, Buitenzorg, D.E.I. which were labelled as follows:—

| | *Description.* | | *Remarks* |
|---|---|---|---|
| *D.* | Prime Samarang | ... | Slightly yellow shade.<br>Very occasional seeds.<br>Fair lustre. |
| *E.* | Average Samarang | ... | Grey colour.<br>Fairly plentiful proportion of seeds.<br>Good lustre. |
| *F.* | Prime Porrong | ... | White colour.<br>Very occasional seeds.<br>Fair lustre. |
| *G.* | Prime Java | ... | Good white colour.<br>Very occasional seeds.<br>Fair lustre. |
| *H.* | Prime East-Java | ... | Grey colour.<br>Fairly plentiful proportion of seeds.<br>Poor lustre. |
| *I.* | Prime Madura | ... | Superior appearance.<br>Slightly yellow shade.<br>No seeds.<br>Good lustre. |

TABLE I.

SHOWING RESULTS OF CHEMICAL ANALYSIS OF KAPOK

| —— | Sample A. | Sample B. | Sample C. | Sample D. | Sample E. | Sample F. | Sample G. |
|---|---|---|---|---|---|---|---|
| | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. | per cent. |
| Moisture - | 8.25 | 10.55 | 11.5 | 10.5 | 11.0 | 11.5 | 10.84 |
| | The following results are calculated on the moisture-free samples. | | | | | | |
| Ash - | 1.56 | 1.56 | 1.00 | 1.27 | 0.90 | 1.36 | 1.40 |
| Water washing loss - | 1.94 | 2.45 | 1.53 | ... | ... | ... | ... |
| Acid washing loss - | 2.99 | 3.23 | 8.04 | ... | ... | .. | ... |
| Hydrolysis A loss - | 23.96 | 23.23 | 23.3 | 21.05 | 19.4 | 21.61 | 18.42 |
| Hydrolysis B loss - | 30.64 | 29.39 | 29.21 | 29.91 | 27.64 | 26.78 | 27.04 |
| Cellulose - | 62.04 | 62.76 | 67.6 | 59.39 | 59.15 | 57.17 | 57.93 |

*Chemical Examination.*—The samples were examined according to the procedure of Cross and Bevan which is followed at the Imperial Institute. It was found necessary to give the material a preliminary wetting with dilute alcohol before the usual treatment. The wetting was carried out in a Gooch crucible, the spirit was sucked off and the specimen was immediately placed in the alkali for hydrolysis. The results obtained are recorded in table I. (page 98.)

*Buoyancy.*—An endeavour was made to establish a laboratory test for determination of the buoyancy of small samples of kapok with a view to ascertaining the factors which affect the buoyancy.

Weighed quantities of air dry kapok were placed in butter-muslin bags containing a test tube fitted with a small funnel. The whole was then floated in water by the addition of a few drops of mercury and the weight in water was recorded. A weighed quantity of kapok was placed in the bag and the weighed tube and bag of kapok were then sunk in a cylinder of water which had a tap at the point of overflow.

The sinking weight was determined by the difference in weight of mercury dropped into the tube from the contents of a weighed beaker. The volume occupied by the kapok at the time of sinking was ascertained by opening the overflow tap of the cylinder and running out as much water as possible into a burette.

The following is a series of readings made with one gramme lots of kapok and a bag and tube which weighed 5 grammes in water.

| Test. | Volume of Water displaced by kapok + bag. c.cs. | Wt. of Mercury added to cause kapok to sink. grammes. |
|---|---|---|
| 1 | 43.0 | 32.9 |
| 2 | 41.0 | 36.9 |
| 3 | 38.0 | 36.2 |
| 4 | 40.0 | 33.0 |
| 5 | 45.0 | 30.0 |
| 6 | 42.0 | 37.8 |
| Average | 41.8 | 34.6 |

Volume of water displaced by bag = 5.0 ccs.
Therefore the sinking weight of 1 gramme of kapok per 1 cc of volume occupied = 0.946 grammes.

A further test was carried out with 4 grammes of kapok in six different sized bags, the object being to see how closely the sinking weight depended on the volume occupied by the kapok.

The figures obtained were as follows:—

| Test | Volume of water displaced by bag ccs. | Volume of water displaced by kapok + bag. ccs. | Volume of kapok ccs. | Total Wt. required to sink kapok. grammes. | Ratio Weight / Volume. |
|---|---|---|---|---|---|
| 1 | 84 | 158 | 104 | 85.6 | 0.84 |
| 2 | 90 | 208 | 118 | 103.8 | 0.85 |
| 3 | 76 | 218 | 142 | 121.8 | 0.85 |
| 4 | 86 | 220 | 134 | 114.3 | 0.86 |
| 5 | 78 | 226 | 148 | 125.1 | 0.84 |
| 6 | 94 | 224 | 150 | 127.9 | 0.84 |

A series of readings was made with kapok enclosed in containers of different sizes made from thin wire mosquito netting.

The dimensions and weights of the containers in water were as follows:—

| | | | |
|---|---|---|---|
| a. | 2″ x 2.5″ x 2.5″ | ... | 3.87 grammes. |
| b. | 3″ x 2.5″ x 2.5″ | ... | 5.40 do. |
| c. | 4″ x 2.5″ x 2.5″ | ... | 6.45 do. |
| d. | 5″ x 2.5″ x 2.5″ | ... | 9.20 do. |

The kapok in gramme lots was spread out in each container which was then sunk in a cylinder of water by adding weights to the top of the container.

| Volume of water displaced by container alone ccs. | Volume of water displaced by container + kapok ccs. | Total weight required to sink container+kapok grammes. | Ratio Weight / Volume. |
|---|---|---|---|
| a. 4 | 74 | 61+8.8 | 0.92 |
| b. 4 | 74 | 67+5.4 | 1.04 |
| c. 4 | 78 | 71+6.4 | 1.04 |
| d. 4 | 74 | 65+9.2 | 1.02 |

A further series of readings using the same wire gauze containers but double the weight of kapok gave the following figures.

| Volume of water displaced by container ccs. | Volume of water displaced by container + kapok ccs. | Total weight to sink container+ kapok grammes. | Ratio Weight / Volume. |
|---|---|---|---|
| a. 4 | 76 | 69+3.8 | 1.0 |
| a. 4 | 98 | 88+5.4 | 0.99 |
| a. 4 | 122 | 105+6.4 | 0.93 |
| a. 4 | 146 | 130+9.2 | 0.98 |

Further determinations of buoyancy were carried out on samples of the dry kapok and on the material after it had been floating on water for 24 hours in a manner conformable with the Board of Trade specification. The tests were made on 1.5 gramme lots disposed as openly as possible in a wire cage 6 x 4 x 4 = 96 cubic centimetres. The cage and its contents were sunk by the addition of weights direct to the floating mass. In the tests on the kapok after floating for 24 hours it was found that the water held by the wire meshes of the cage led to variable results. This could be overcome by shaking vigorously before adding the weights for sinking. The results recorded in Table II are the mean figures for a series of six determinations on each sample.

TABLE II.

Showing records of buoyancy tests on kapok samples. *Samples sunk without previously floating in water.*

| Samples. | Volume displaced by kapok c.cs. | Weight to sink kapok grammes. | Ratio Weight / Volume. |
|---|---|---|---|
| Serdang kapok - | 76.0 | 92.0 | 1.21 |
| Prime Samarang kapok - | 75.4 | 91.4 | 1.21 |
| Prime Porrong kapok - | 71.8 | 87.3 | 1.22 |
| Average Samarang kapok | 76.4 | 92.0 | 1.20 |
| Prime East Java kapok - | 72.5 | 88.5 | 1.22 |
| Prime Madura kapok - | 73.3 | 89.6 | 1.22 |

*Samples sunk after floating for 24 hours.*

| | | | |
|---|---|---|---|
| Serdang kapok - | 81.1 | 96.0 | 1.18 |
| Prime Samarang kapok - | 86.3 | 98.6 | 1.14 |
| Average Samarang kapok - | 81.0 | 97.0 | 1.20 |
| Prime Porrong kapok - | 83.8 | 96.0 | 1.15 |
| Prime Java kapok - | 84.8 | 98.0 | 1.16 |
| Prime East Java kapok - | 84.0 | 96.0 | 1.14 |
| Prime Madura kapok - | 87.0 | 100.0 | 1.15 |

With the object of gaining further information on the buoyancy of kapok some samples were examined, by the method elaborated above, before and after extraction with petrol ether. The extraction was carried out on 2 gramme lots for 24 hours in Soxhlet extractors in the usual manner.

Eight samples of kapok which were extracted showed a loss in weight of 10 to 13.5 per cent calculated on the moisture-free material.

The results obtained for buoyancy determinations on the samples before and after extraction were as follows:—

| Sample. | Before Extraction. | | | After Extraction | | |
|---|---|---|---|---|---|---|
| | Volume displaced by kapok ccs. | Weight to sink kapok grammes. | Ratio Weight / Volume. | Volume displaced by kapok ccs. | Weight to sink kapok grammes. | Ratio Weight / Volume |
| C. Serdang | 76.0 | 92.0 | 1.21 | 76 | 92 | 1.21 |
| D. Prime Samarang | 75.4 | 91.4 | 1.21 | 79 | 98 | 1.24 |
| F. Prime Porrong | 71.8 | 87.3 | 1.22 | 71.5 | 88 | 1.23 |

It is evident from these figures and others collected but not recorded above that the extraction of kapok by a fat solvent does not affect the bouyancy of the material.

*Microscopical Examination.*—Some measurements of the ultimate length of fibre were made on specimens taken from three of the samples. One gramme lots were boiled with 2

per cent caustic soda for an hour and the material after washing free from soda was washed out into a Winchester quart of water and shaken to separate the fibres. Specimens were removed to slides and examined microscopically. The ultimates fibres or hairs are cylindrical with a perfectly smooth exterior and very thin cell walls. They are thick at the base and taper at one end to a fine point. The other end frequently forms a round knob to which fibrillae are attached in some cases. The cross section is circular and not flat as in the case of cotton.

The fibres were found to stain brown with iodine, and violet blue with chlorzinc—iodine. With cuprammonium solution the fibres became crinkled and corrugated but showed no swelling. With aniline sulphate there was no colouration. Measurements of ultimate length were made on a number of fibres of each specimen and the mean results were as follows:—

| | | | |
|---|---|---|---|
| C. | Serdang kapok. | Ultimate Length. | 6.5 millimetres. |
| D. | Prime Samarang. | do | 7.5 millimetres. |
| E. | Average Samarang. | do | 10.0 millimetres. |

The figures are somewhat lower than those recorded by the Imperial Institute (1) and by M. M. Saleeby (2) but the difference is not significant.

*Conclusions.*—The investigations show that the samples of kapok examined do not vary materially with regard to their chemical or physical characteristics and that it has not been possible to differentiate between samples by a determination of buoyancy by a simple laboratory method.

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(1) Bulletin. Imperial institute. Vol. 24. No. 1. 1926.

(2) The Kapok Industry. Bull 26. Bureau of Agriculture Philippine Islands.

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# A Preliminary Report on Tapioca as a Catch-Crop with Oil Palms.

J. Lambourne.

For many years it was thought unwise to plant tapioca (*Manihot utilissima*) as a catch-crop with more permanent cultivations such as rubber or coconuts, and until recently the Government* has not encouraged the cultivation of this crop as it was thought to be a very exhausting one and likely to do permanent injury to any crop among which it was grown. The experiment described below was commenced with a view to finding out the effect of tapioca cultivation as a catch-crop. Five one-acre plots were laid down in the oil palm area Block No. 21 at the Experimental Plantation, Serdang to determine this point.

Since these plots were laid down, information has come to hand of an estate in Province Wellesley having been planted with tapioca, as a sole crop at first, and later as a catch-crop with rubber. This was carried on for a number of years and it was found that, by judicious manuring, good crops were obtained and no appreciable harm resulted to the rubber, in fact, it is reported that the trees are as good, and are yielding as well as any of the same age in that district (see *Malayan Agricultural Journal*, Vol. XIV, No. 11, 1926 page 361).

As the oil palm appeared to be a coming crop, it was decided to lay down a number of plots to ascertain whether certain quick-growing plants could be used to assist in covering the land between the palms for a number of years, and at the same time give a return which would help to pay the cost of bringing the main crop into bearing without unduly retarding it. Tapioca was selected as one of these on account of its being an excellent food-crop and because of its potential use as a source of power alcohol. The area under tapioca was five acres divided into one-acre plots.

At the time of planting the tapioca cuttings (February, 1925) the oil palms had been planted in the field only for a few months. The area on which they were planted had been previously under light blukar. This was cleared of all stumps and the area where the tapioca catch-crop experiment is being carried out was ploughed and disc-harrowed twice previous to planting the oil palms.

## Date and Method of Planting.

The tapioca was planted in February, 1925 and the planting material used was from five varieties imported from the Philippine Islands in March, 1923. These were planted in the nursery and stocks were increased until there

* Government Gazette Notification No. 1964 of 1st April, 1927.

was enough material to plant one acre of each variety. The area selected for the experiment was a strip of nine rows of palms running East and West. These were divided into five one-acre plots, a different variety of tapioca being planted in each. The control plots, consisting of a strip of nine rows of palms by the side of this area, are clean weeded.

The oil palms are planted 28 ft. by 28 ft. triangular, the rows running East and West being approximately 24 ft. apart (i.e. the vertical height of the triangle). The tapioca cuttings were planted in five rows 3 ft. by 3 ft. on the middle twelve feet between the rows of palms, leaving six feet from the palms on either side. The area under tapioca in each acre plot was 0.604 acre (approximately 3/5 acre).

### Cost of Planting the Tapioca.

The cost of planting was as follows:—

| | | |
|---|---|---|
| Preparation of cuttings | - | $3.00 |
| Transport and planting | - | 11.40 |
| Total | $ | 14.40 |

This is equivalent to $2.88 per acre of oil palms interplanted with tapioca. It must be noted that no cultivation charges have been made, the cost of ploughing and disc-harrowing with the tractor would be about $10/- per acre.

The five varieties of tapioca used were as follows, both the plantation number and the name under which they were received from the Philippine Islands being given:—

| *Plantation No.* | *Name under which introduced.** |
|---|---|
| Philippine No. 1 | ... Casjane Singkong Manis |
| ,, 2† | ... Mandioca Sao Pedro Preto |
| ,, 3 | ... Aipin Mangi |
| ,, 4 | ... Mandioca Basiorao |
| ,, 5 | ... Kapo green |

After the cuttings were planted the only cultivation given was the monthly weeding similar to the rest of the area.

### Harvesting.

The crop was harvested in June, 1926, approximately sixteen months after planting. The tubers were ripe before this but, owing to other important work in hand, it was not possible to harvest before.

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* For information regarding these varieties see M.A.J., Vol. XV, No. 2.

† Bitter (Poisonous.)

For the purpose of calculating yields, each acre plot was divided into nine sub-plots of 0.067 acre each, that is, the area between every two rows of palms that was planted with tapioca. At the time of planting there were five rows of 65 cuttings each; there should have been, therefore 325 plants in each sub-plot and 2,925 in the acre plot. There were a number of vacancies, however, and the actual number of plants to reach maturity were, in some cases, considerably less than this.

While harvesting, both the tubers and tops, (stems and leaves) were weighed, so that the total weight of material taken off the land could be calculated and expressed in terms of plant food materials taken from the soil. The cost of harvesting was $22.50 per acre, but this includes the weighing of both tubers and tops in the field which was expensive and under ordinary conditions expenditure on weighing the tops would not be incurred. Reasonable costs would be $10/- to $12/- per acre according to crop.

## Yields.

The actual weight of tubers and tops harvested from each acre plot is given in Table I and the calculated yield per acre of land actually planted with tapioca in Table II. The weights of tubers and tops per plant, together with the number of plants harvested from each plot, and the number of vacancies which occurred are shown in Table III. It will be seen that the number of vacancies is large, approaching 50% in one plot. It will also be noticed that the proportion of tubers to tops is much larger in the two heaviest yielding varieties. None of the varieties have yielded particularly well although they are all above the average for local varieties grown at Serdang, with perhaps the exception of Philippine No. 3, which is normally a very poor yielder.

TABLE I.

| Plantation No. | Total Yield tubers, lbs. | Total yield tubers, piculs. | Total yield tubers, lbs. | Total yield tubers, lbs. |
|---|---|---|---|---|
| Philippine No. 1 | 10,885 | 81.01 | 18,663 | 139.97 |
| " 2 | 12,425 | 93.19 | 6,166 | 46.24 |
| " 3 | 6,123 | 45.92 | 10,122 | 75.92 |
| " 4 | 15,237 | 114.25 | 9,810 | 73.58 |
| " 5 | 9,843 | 73.82 | 16,455 | 123.41 |

## TABLE II.

*Yields per acre calculated from Table I. Area = 3.5 acre.*

| Plantation No. | Total yield tubers, lbs. per acre. | Total yield tubers, piculs per acre. | Total yield tops, lbs. per acre. | Total yield tops, piculs per acre. |
|---|---|---|---|---|
| Plantation No. 1 | 18,058 | 135.44 | 31,105 | 233.29 |
| ,, 2 | 20,708 | 155.31 | 10,277 | 77.08 |
| ,, 3 | 10,205 | 76.79 | 16,870 | 126.58 |
| ,, 4 | 25,395 | 190.46 | 16,350 | 122.63 |
| ,, 5 | 16,405 | 123.04 | 27,425 | 205.69 |

## TABLE III.

*Yields of tubers and tops calculated per plant, together with the number of plants harvested from each plot, and the vacancies which occurred.*

| Plantation No. | Total weight tubers. | No. of plants harvested. | Average weight tubers per plant. | Total yield tops. | Yield tops per plant. | No. of vacancies. | Comparison of yield of tubers mean = 100 |
|---|---|---|---|---|---|---|---|
| | lbs. | | lbs. | lbs. | lbs. | | |
| Philippine No. 1 | 10,835 | 2,024 | 5.4 | 18,663 | 9.2 | 901 | 99.5 |
| ,, 2 | 12,425 | 1,556 | 8.0 | 6,166 | 4.0 | 1369 | 114.1 |
| ,, 3 | 6,123 | 1,927 | 3.2 | 10,122 | 5.3 | 998 | 56.2 |
| ,, 4 | 15,237 | 2,296 | 11.8 | 9,810 | 4.3 | 629 | 139.9 |
| ,, 5 | 9,842 | 2,230 | 4.4 | 16,455 | 7.4 | 695 | 90.4 |

The following tables contain calculations based on a report of the analysis of the Philippine varieties of tapioca when they were grown in the Nursery in February, 1925. This report is by Mr. J. H. Dennett, Assistant Agricultural Chemist, S.S. & F.M.S., and his figures have been used to calculate the amount of the various plant food constituents that have been taken from the soil by the crop recently harvested from among the oil palms.

TABLE IV.

*Percentage of Tuber and Top to Plant calculated on the crop harvested from among the oil palms.*

| Plantation No. | Total weight tubers per plot. | Total weight tops per plot. | Total weight of plant per plot. | Percentage. | |
|---|---|---|---|---|---|
| | | | | Tubers. | Tops. |
| | lbs. | lbs. | lbs. | | |
| Philippine No. 1 | 10,835 | 18,663 | 29,498 | 36.4 | 63.6 |
| „ 2 | 12,425 | 6,166 | 18,591 | 66.8 | 33.2 |
| „ 3 | 6,132 | 10,122 | 16,254 | 37.7 | 62.3 |
| „ 4 | 15,237 | 9,810 | 25,047 | 60,8 | 39.2 |
| „ 5 | 9,843 | 16,455 | 26,298 | 37.4 | 62.6 |

TABLE V.

The following table gives the calculated weight of dry matter and ash taken with the crop of tapioca harvested from each acre plot of oil palms, calculated on the yields given in Table IV.

| Plantation No. | Moisture % | | Total weight dry matter | Percentage Ash on dry material | | Total weight of ash |
|---|---|---|---|---|---|---|
| | Tubers | Tops | | Tubers | Tops | |
| | | | lbs. | | | lbs. |
| Philippine No. 1 | 64.7 | 68.0 | 9,797 | 1.27 | 2 49 | 197 |
| „ 2 | 75.0 | 76.4 | 4,561 | 1.29 | 3·31 | 93 |
| „ 3 | 73 9 | 76.8 | 3,949 | 1.38 | 2.62 | 84 |
| „ 4 | 70.1 | 72.6 | 7,244 | 1.93 | 2.28 | 148 |
| „ 5 | 71.3 | 73.3 | 7,218 | 1.65 | 2.64 | 163 |

Table VI below gives the ash constituents and nitrogen taken from the soil by the tapioca crop harvested from the oil palm area, calculated to pounds per plot from results of analyses by the Assistant Agricultural Chemist and crop figures given in Table IV above.

TABLE VI.

| Constituents calculated on fresh material. | P. No. 1 lbs. per plot. | P. No. 2. lbs. per plot. | P. No. 3 lbs. per plot. | P. No. 4 lbs. per plot. | P. No. 5 lbs. per plot. |
|---|---|---|---|---|---|
| Potash as $K_2O$ | 53.69 | 23.72 | 23.6 | 49.37 | 44.10 |
| Calcium as Ca O | 34.37 | 17.67 | 20.06 | 17,63 | 21.11 |
| Phosphates as $P_2O_5$ | 14.46 | 7.23 | 8.62 | 13.05 | 14.40 |
| Magnesium as Mg. | 3.24 | 2.37 | 1.98 | 3.49 | 3.47 |
| Nitrogen as N. | 58.18 | 35.50 | 42.80 | 65.61 | 78.61 |

According to the results of analyses of tubers and stems there is considerable variation in the percentage of food constituents in the different varieties of tapioca. The stems contain a much greater percentage of ash constituents and also nitrogen than the tubers as the following table shows. The figures below are averages of the five varieties taken from Tables V and VI in Mr. Dennett's report and in this instance the analysis of the stems do not include the leaves, which only amount to about 1% of the total fresh material.

| Constituents. | Tubers. | Stems. |
|---|---|---|
| | % | % |
| Potash as $K_2O$ - | 0.171 | 0.172 |
| Calcium as CaO - | 0.042 | 0.152 |
| Phosphates as $P_2O_5$ - | 0.029 | 0.067 |
| Magnesium as Mg. - | 0.011 | 0.016 |
| Nitrogen as N. - | 0.134 | 0.383 |

The above figures are calculated on the fresh material. Taking the average of the yields from the five plots and using the above percentages for the purpose of calculating the amount of the various constituents taken from the soil the following figures are arrived at:—

| | Lbs. per plot | | |
|---|---|---|---|
| | In Tubers | In Tops. | In Whole Plant |
| Potash as $K_2O$ ... ... | 18·62 | 21·05 | 39·67 |
| Calcium as CaO ... ... | 4·57 | 23·61 | 28·18 |
| Phosphate as $P_2O_5$ ... | 3·16 | 8·20 | 11·36 |
| Magnesium as Mg ... | 8·20 | 2·46 | 3·66 |
| Nitrogen as N ... ... | 14·60 | 46·89 | 61·49 |

The above calculations are based on the weight of the whole plant including the leaves present on the stems and branches at harvest and the percentages of the various constituents are those found in the tubers and stems. In ordinary practice the tops would probably be left on the land for a time after harvest and most of the leaves would drop off and decay, thus some of the organic materials that have been taken with the crop would be returned to the soil. Calculated as "artificial manures" the above figures are equivalent to:—

| | Per plot. |
|---|---|
| Sulphate of Potash 50% $K_2O$ ... | 80 lbs. |
| Superphosphate (Concentrated) 40% $P_2O_5$ ... | 30 ,, |
| Sulphate of Ammonia 20% N ... | 310 ,, |

It is assumed, for purposes of replacement, that the potash will be replaced by sulphate of potash, the phosphates and lime by superphosphate, and the nitrogen by sulphate of ammonia. The magnesium and chlorides are taken up by the plant in very small quantities and enough will probably be found in the soil or as impurities in the manures.

### Effect of Tapioca on the Growth of Oil Palms.

The question is often asked whether tapioca retards the growth of oil palms when grown as a catch crop among them. In this connection the figures given in Tables VII and VIII are of interest.

## TABLE VII.

Growth measurements of oil palms taken from the plots on which tapioca varieties were grown as a catch-crop together with those from the control plots, Measurements were taken in December, 1925, June, 1926 and January, 1927.

| Plot No. | Dec. 1925 Average height | June 1926 Average height | June 1926 Average spread | January 1927. Average height | January 1927. Average spread | |
|---|---|---|---|---|---|---|
| | ft. ins. | ft. ins. | ft. ins. | ft. ins. | ft. ins. | |
| 3 A | 4 4 | 5 3 | 9 4 | 8 2 | 11 2 | Tapioca plots |
| 3 B | 4 2 | 5 1 | 9 2 | 8 2 | 11 4 | |
| 3 C | 2 1 | 4 5 | 8 0 | 7 4 | 10 4 | |
| 3 D | 3 8 | 4 7 | 7 9 | 7 3 | 10 1 | |
| 3 E | 2 10 | 3 6 | 6 1 | 6 2 | 8 5 | |
| 4 A | 4 10 | 5 10 | 10 8 | 6 5 | 11 0 | Control plots |
| 4 B | 4 8 | 5 9 | 10 2 | 6 4 | 10 7 | |
| 4 C | 4 5 | 5 6 | 9 4 | 6 3 | 10 2 | |
| 4 D | 4 2 | 5 8 | 9 8 | 6 5 | 10 3 | |
| 4 E | 2 8 | 3 7 | 6 3 | 4 6 | 6 9 | |

## TABLE VIII.

*Increases in Height and Spread.*

| Plot No. | Increase in Height. Dec. 1925 to June 1926 | Increase in Height. June 1926 to Jan. 1927 | Increase in Height. Dec. 1925 to Jan. 1927 | Increased spread June 1926 to Jan. 1927 | |
|---|---|---|---|---|---|
| | ft. ins. | ft. ins. | ft. ins. | ft. ins. | |
| 3 A | 0 11 | 2 11 | 3 10 | 2 5 | Tapioca plots |
| 3 B | 0 11 | 3 1 | 4 0 | 2 2 | |
| 3 C | 2 4 | 2 11 | 5 3 | 2 4 | |
| 3 D | 0 11 | 2 8 | 3 7 | 2 4 | |
| 3 E | 0 8 | 2 8 | 3 4 | 2 4 | |
| 4 A | 1 0 | 0 7 | 1 7 | 0 4 | Control plots |
| 4 B | 1 1 | 0 7 | 1 8 | 0 5 | |
| 4 C | 1 1 | 0 9 | 1 10 | 0 10 | |
| 4 D | 1 9 | 0 9 | 2 3 | 0 7 | |
| 4 E | 0 11 | 0 11 | 1 10 | 0 6 | |

In explanation of these figures it should be noted that, when the palms were first measured the tapioca had been planted ten months and the crop remained on the land for a further six months before it was harvested. The June measurements were taken about the time the tapioca crop was taken off the land. During the past six months, i.e. June, 1926 to January, 1927, the five catch-crop plots under review have been ploughed and disc-harrowed while the control plots have been disc-harrowed only.

On plots 3 A and 3 C a crop of Horse Gram (*Dolichos biflorus*) has been grown and changkolled in, after which another lot of tapioca cuttings were planted, while plots 3 B and 3 D were planted with tapioca just after the ploughing and disc-harrowing had been completed. Plot 3 E has been planted with Ramie Fibre (*Boehmeria nivea*).

It will be seen that the control plots made a slightly larger increase in growth during the first six months, while the tapioca was on the land, but during the last six months the tapioca plots have increased in growth three times as quickly as the controls and much the same result is shown by the figures for increase over the whole year. Although the palms in the tapioca plots were smaller when the first measurements were taken they have now grown slightly larger than those in the controls plots, the difference, however, is not very apparent to the eye. There is no doubt that the extra cultivation given to the tapioca plots both in harvesting the tapioca crop and preparing the soil for the next one has greatly benefitted the palms. It must be borne in mind that the above results are only those for the first year and it remains to be seen whether the palms in the tapioca plots will compare favourably with those in the controls. Of course, it is possible that the present crop may have to be the last as the rows of tapioca between the palms have had to be reduced to four this year owing to the increased size of the palms.

## Summary.

1. The layout of the experiment and the methods of planting and harvesting the crop have been described.

2. Tables showing the yield of both the tubers and tops harvested are given. These show that the crop obtained from Philippine Nos. 2 and 4 are good, and those from Nos. 1 and 5 are only fair, while No. 3 is a very poor yielder. It will be seen that those varieties with a small amount of tops yield the heaviest crop of tubers.

3. The amount of ash constituents and nitrogen taken from the soil with the crop for each variety are shown in lbs. per plot, (Table VII). The average amount of plant food constituents taken from the soil with the crop together with their equivalent in chemical manures has been worked out.

It has been found that, with the exception of potash, the tops contain a much greater percentage of ash constituents and nitrogen than the tubers. There is also a considerable variation in the percentage of the various plant foods in the different varieties of tapioca.

4. The growth measurements of the oil palms in both the tapioca and control plots are given in Tables VIII and IX. Although the growth of the palms was not so good in the tapioca plots during the time the crop of tapioca was on the ground they have increased in size much quicker than they have in the controls since the first crop has been harvested, consequently they are now slightly larger than those in the controls. This is no doubt due to the cultivation received by those plots during harvesting of the tapioca crop and subsequently in carrying out the second planting.

5. It is pointed out that the figures given are those for the first crop of tapioca only. It will be interesting to see how many crops of tapioca can be taken from these plots without detriment to the oil palms.

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## Chaulmoogra and Hydnocarpus Oils.

Much interest has been evinced in the question of successful treatment of Leprosy by Vegetable Oils—e.g. Chaulmoogra Oil. The first article No. (1) appeared in the *Bulletin of Miscellaneous Information* issued by the Royal Botanic Gardens Kew (*K. B.* No. 1, 1926) and was prepared by Dr. T. A. Henry, Director of the Wellcome Research Laboratories. The extract (1A) is a later authoritative statement which appeared in *Nature*, Vol. 119, No. 2992, p. 362.

The Department of Agriculture, Federated Malay States and Straits Settlements was fully alive to the importance of the work being carried on and seeds of *Hydnocarpus spp.* and *Taraktogenos Kurzii* were obtained and planted at the Government Experimental Plantation, Serdang. The observations made over the last three or four years are recorded in the article No. (2) succeeding the above; this article has already appeared in the *Kew Bulletin*, No. 2, 1926, but later observations (2A) have been incorporated. The various articles are gathered together and reproduced here for the convenience of interested parties.

(1)—The Treatment of Leprosy by Vegetable Oils.

The recent history of the successful use of these two oils in the treatment of leprosy begins with the discovery by Sir David Prain in 1901 that chaulmoogra oil is derived from *Taraktogenos Kurzii* King and not from *Gynocardia odorata* R. Br. as had been supposed up to that time. It thus became possible to secure well-authenticated material for chemical investigation.

In 1904, Dr. F. B. Power and his co-workers began the publication of the results of their chemical researches on this subject (Trans. Chem. Soc. 1904, Vol. 85, pp. 838, 851; 1905, Vol. 87, pp. 349, 884, 896; 1907, Vol. 91, p. 557) which, among other interesting facts elicited, showed that these two oils contain as their principal constituents chaulmoogric and hydnocarpic acids, the first of a new group of acids now known as the chaulmoogric series. These two acids proved to be closely related and to be unique among naturally-occurring fatty acids in having a cyclic structure and in being optically active. These results have been amply confirmed by later investigators and it has also been found that the same two acids occur in other species of *Hydnocarpus*, besides *H. Wightiana* Blume and *H. anthelmintica* Pierre originally examined by Power (Brill; Phil. Journ. Sci. 1916, Vol. 11, p. 75; 1917, Vol. 12, p 37), and in other genera such as *Asteriastigma macrocarpa* Bd. (Ghosh. quoted by Rock, U.S.A. Dept. Agric. Bulletin No. 1051) and *Oncoba echinata* Oliv. (Goulding and Akers, Proc. Chem. Soc. 1913, Vol. 29, p. 197). The latter known as "Gorli" in Sierra Leone contains chaulmoogric but no hydnocarpic acid.

Although both chaulmoogric and hydnocarpus oils had long been known as remedies for leprosy and skin diseases, their value was regarded by medical men as uncertain, and as the oils obtainable were often dirty, rancid and unpleasant and were given by the mouth, it was not unusual for patients to be nauseated by them long before any good effect could be produced. Oral administration has now been almost entirely superseded by injection, and it is to the provision of derivatives of the oils suitable for this improved technique that recent progress in the treatment of leprosy is largely due. Material suitable for injection was available so long ago as 1879 when Moss prepared "Gynocardic acid," which eventually, in the form of "Sodium gynocardate," really a chaulmoogra oil soap, soluble in water, became a commercial article. This name, which still crops up in chemical and medical literature, is an unfortunate reminder of the mistaken view that chaulmoogra oil is derived from *Gynocardia odorata*. Power and his co-workers also prepared water-soluble salts of their pure chaulmoogric and hydnocarpic acids, and, what is more interesting in view of recent developments, methyl and ethyl esters of these acids. Clinical trials were made about that time with some of these products but the results were not striking enough to warrant their introduction into medicine, probably because the trials were not carried on for the long period now known to be necessary to ensure sucess. The first real advance* on the medical side was made by Sir Leonard Rogers, who began work in India about 1915 (Lancet, Feb. 5, 1916; Indian Journal of Medical Research, 1917, vol. 5, p. 277). He used at first sodium salts of the total fatty acids of both chaulmoogra and hydnocarpus (*H. Wightiana*) oils but eventually got the best results with sodium salts of fractions of the fatty acids rich in hydnocarpic acid. The latter acid melts at 60°C. and Roger's best fractions had melting points 57—58°C. and 60—62°C., whereas chaulmoogric acid melts at 68.5°C.

Somewhat later, at the suggestion of the Director of Leprosy Investigation in the Philippine Islands, Professor Dean prepared the ethyl esters of the mixed fatty acids of chaulmoogra oil, i.e., the mixed ethyl esters of chaulmoogric and hydnocarpic acids. With this material, clinical work has been carried on with great success during the last six years (Hollman and Dean, Journ. Cutaneous Diseases, vol. 37, No. 6; McDonald, Journ. Amer. Med. Assoc., 1920, vol. 75, p. 1483, vol. 76, p. 1121; 1921, vol. 78, p. 1470) in the Philippines and elsewhere. In India Muir has used the ethyl esters of *Hydnocarpus Wightiana* oil with equal success, though not perhaps on the large scale that has been possible in the Philippines. Similarly esters made from *H. anthelmintica* oil have been used in Siam and China.

*During the last 20 years research on these oils, especially on the bacteriological and medical sides, has been particularly active, and in this note only the results which are of special importance can be referred to. Several of the publications quoted contain selected bibliographies which will be useful to those who desire fuller information.

Commenting on the results of all this work, Rogers and Muir (Leprosy: John Wright and Sons, Bristol, 1925, p. 288) say:—

"The improved methods of dealing with leprosy have therefore placed in our hands a simple and effective means of diminishing the disease by providing treatment, under attractive conditions, for early, little or non-infective cases in out patient dispensaries, and more advanced infective types in sanatoria and colonies, only funds and organization being required to bring about a great decrease of the disease in all countries where these advantages can be supplied to a large proportion of the lepers."

The value of chaulmoogra and hydnocarpus oils or of their derivatives having thus been demonstrated, enquiries have naturally been made as to the possibility of using other oils in which acids of the chaulmoogric series have been found. In 1923 Mr. M. T. Dawe, Commissioner of Lands and Forests, Sierra Leone, kindly provided me with a supply of Gorli seed, which as stated above had been shown in 1913 by Goulding and Akers at the Imperial Institute to contain over 45 per cent. of oil, rich in chaulmoogric acid.

The oil was extracted from Mr. Dawe's material in these laboratories and the esters of the total fatty acids prepared. The Director of Leprosy Investigations in the Philippines tried these esters in cases of leprosy but found them unsuitable as a substitute for chaulmoogra esters. This result is surprising in view of the fact that the only difference between Gorli and chaulmoogra esters is that hydnocarpic acid is absent from the former. Both sets of esters contain chaulmoogric acid and the latter acid is so like hydnocarpic acid in constitution that it ought to have the same therapeutic action. As this matter is of considerable theoretical interest and practical importance it is being further investigated, but until this and other similar questions are settled by experimental work it would seem to be advisable to confine attention to the oils from the three species already known to yield satisfactory products containing both acids, viz., *Taraktogenos Kurzii*, *Hydnocarpus Wightiana* and *H. anthelmintica*.

An interesting side-issue in this connection is a proposal to treat leprous patients by giving them *Taraktogenos* or *Hydnocarpus* seeds to eat. So long as this is done under medical supervision there is probably nothing to be said against it, but the process is so simple that it may appeal to the benevolent layman as a means of assisting sufferers from this disease. It is well to bear in mind therefore that the seeds of all these species so far examined have been found to contain cyanogenetic glucosides, which liberate small quantities of prussic acid when the seeds are ground up in a moist condition, and that the oils they contain are toxic. It is on record, for example, that a Hydnocarpus oil imported

into Hamburg in 1911 and used for the manufacture of edible products gave rise to poisoning cases.

All the species referred to above belong to the Natural Family *Flacourtiaceae* and, with the exception of *Oncoba echinata* Oliv. (*Caloncoba echinata* Gilg.) which occurs in Western Tropical Africa, they are trees distributed through the tropical evergreen forests of the East Indies, up to altitudes of 4,000 ft. Our field knowledge of these trees and other allied species we owe chiefly to Dr. J. F. Rock who, in 1919, carried out a survey of the localties in which these trees were reported to grow, and whose observations are recorded in the U.S. Dep. Agric. Bull. No. 1057 of the 24th April, 1922.

Dr. Rock states that so far as he could ascertain the dealers in chaulmoogra oil have never seen the trees in their wild state. Even the native Bengal dealers whom he met in Chittagong had not been in the forests of the Chittagong Hill tracts. They all depend for their supplies on the seeds collected by the jungle people who know them by different native names in different localities. The Burmese name "Kalaw" is applied to more than one species, and as the different species closely resemble each other they are sent to the markets and bazaars under the collective name of Kalaw, where they are bought by the dealers.

So far as Dr. Rock's observations extended these trees do not appear to bear a regular yearly crop but fruit sporadically and sometimes do not bear fruit at all for two years or more. The exact reason of this he was not able to give; he notes, however, that the trees are polygamous and are undoubtedly insect-pollinated.

It does not appear that a sufficient and constant supply of seeds of known identification will ever be able to be obtained from trees in the wild state, and plantations will be necessary if a constant supply of authentic material should be required. The remoteness from any civilised centres of the forests where these trees occur, the dangers from animals and the difficulties encountered in collecting the seeds all emphasise this point.

The following notes on the climate and natural conditions in which *Taraktogenos* occurs are given by Dr. Rock as a guide to prospective planters of these trees. The soil should be of a sandy nature, preferably quartz sand. Perfect drainage is necessary, and undulating or hilly land is preferable. The region should have a distinct rainy season with a pronounced dry season in the winter months, but still with considerable humidity. The winter temperature should not fall below 40° F. *Hydnocarpus* requires slightly different conditions, but all species require well-drained sandy or loamy silt soils and grow best along creek beds or on the banks of streams; all require climates of the tropical evergreen rain forest.

On arrival at the factory the seeds are carefully washed, sundried for a day or two, shelled and sorted by hand, and crushed between corrugated rollers. They are then placed to a thickness of about an inch in jute bags about a foot square. Five layers of eight of these bags are pressed at one time. A steel plate is placed above each layer and the whole subjected to hydraulic pressure. The cold drawn oil is collected in tin cans and filtered through ordinary blotting paper. The residual cake, which is still rich in oil and contains about 6 per cent. nitrogenous compounds, is used as a manure on tea plantations and paddy fields.

In the present contribution Dr. Henry draws particular attention to three of the species hitherto under observation, namely, *Taraktogenos Kurzii* King, *Hydnocarpus Wightiana* Blume, and *H. anthelmintica* Pierre. These species come from quite distinct areas, but all are trees occurring in tropical evergreen forests.

The genus *Taraktogenos* occurs in Assam, Burma, Indo-China, Malay and the Dutch East Indies; twelve species are so far known. It seems possible that there is more than one species known under the name of *T. Kurzii* King, and in the following notes the references to the Burmese and Assam plants have been kept separate. The herbarium material, especially that of flowering specimens, is very scanty and the investigation cannot be carried further until additional material has been obtained. The Burmese tree, locally known as "Kalaw," is distributed throughout Burma though Rock states it is confined to localities of no great elevation. It occurs in dense tropical humid forests with lower strata of fern and shrubs and generally grows in the quartz sand in the beds and along the banks of streams, and on loamy flat country subject to inundation during the rainy season. It grows to a height of 40 or 50 ft. developing a strong and vigorous taproot and has a straight trunk and smooth, pale, yellowish-brown bark. The branches are at first at right angles to the trunk but are very flexible and soon droop downwards especially under the weight of the fruits which are borne on the ends of the branches. The general appearance of the tree is pyramidal, not unlike an old fir tree. The fruits are round, not pointed at the apex, of a light fawn colour, minutely granular, velvety-tomentose, and are about the size of a large orange. The seeds, which are numerous, are irregularly oval and are embedded in pulp. The fruit matures during the rainy season and then falls to the ground, when it is eagerly sought after by bears and monkeys on account of the fruit flesh.

The Assam plant, locally known as "lemtam," occurs at elevations up to 4,000 ft. in the northern half of Assam. It also is to be found in heavy loamy soil on land subject to inundation and often swampy. More often than the Burmese trees it occurs scattered and frequently in company with *Gynocardia odorata*. Its fruit is ridged especially to-

wards the apex and is darker than the fruits of the trees growing in Burma.

In this connection an interesting communication has been received from Mr. Joseph Jones, who states that in December, 1920, he received at the Botanic Gardens, Dominica, two consignments of seeds through the Royal Botanic Garden, Calcutta. One lot appeared to have come from Assam and one from Burma. From these seeds trees of two growth forms have resulted. Those considered to have come from Burma have produced trees with pendulous branches resembling a fir and with light green leaves whilst the Assam seeds have produced trees of compact growth with ascending branches, shorter internodes and dark green leaves. These Dominica specimens have not yet flowered but Mr. Jones considers they may come into bearing when about 8 years old.

Prof. Craib, in his enumeration of the Siamese *Flacourtiaceae**, merges the genus *Taraktogenos* into *Hydnocarpus* and the species under consideration becomes *H. Kurzii* Warbg. At the same time he recognises a new variety *H. Kurzii* var. *conica* which is distinguished by its oval fruit with a conical apex; the vegetative characters of the herbarium specimens resemble each other closely; the flowers of this variety have not been seen. Although the variety is recorded from Siam Prof. Craib considers that it is likely to occur in Burma as well as the species and that both are included among the specimens cited by King.

It is not possible in the present state of our knowledge to say whether the differences noted by Rock, Jones and Craib concern the same plants, but there appears to be more than one species, variety, or possibly physiological race under the name *Kurzii*.

The genus *Hydnocarpus*, to which the other two species specially mentioned by Dr. Henry belong, is distributed through India, Ceylon, the Andamans, Malay, Indo-China and the Dutch East Indies to the Philippines and New Guinea; thirty-two species have so far been described.

*Hydnocarpus Wightiana* Bl. occurs in tropical evergreen forests of South-Western India along the western Ghats, from North Kanara to Travancore, and is found up to an altitude of 3,000 ft. and attains a height of from 50 to 100 ft. Its trunk is rather slender, sometimes fluted, and the bark is pale brown and somewhat rough. Its white flowers appear in March and April and the fruits from about October to December. The latter are from 2 to 4 inches in diameter, slightly angular, and tomentose; the seeds are numerous, obtusely angular and embedded in pulp. Like *Taraktogenos Kurzii* and the following species it is generally to be found growing near water.

*Florae Siamensis Enumeratio, Part I, 1925, p. 97.

*Hydnocarpus anthelmintica* Pierre, known in Siam as "maikrabao" or "lukrabao," and to the Chinese as "Ta-fung-tze," occurs in Siam and Indo-China up to elevations of 1,000 ft. and is in cultivation at Chiengmai and elsewhere in Siam. It attains a height of 60 ft.; the male flowers appear from January to March, earlier in the year than the female, and perhaps more frequently. The fruits are globose, about three inches in diameter and contain from 30 to 40 seeds. It is generally to be found on the banks of rivers and estuaries where the water table is high.

Although some thousands of plants of these various species have been raised from the seed distributed by Dr. Rock to Honolulu, Washington, the Philippines and Singapore, there are no plantations in bearing from which a reliable supply of seed can be obtained. The only source from which seed can be obtained at present is from native collectors and the origin of such seed is uncertain, but when the trees that have been established in various tropical countries come into bearing in the course of a few years it will be possible to obtain seed of known identity.

The seed quickly loses its vitality and requires to be carefully packed for transmission. The best results so far have been obtained with seed packed in moist powdered charcoal in cotton bags which were wrapped securely in strong oil paper and then in heavy manila paper.

Very little is known at present of this group of plants, which promise to prove of economic importance. Further investigation in the field, additional material for herbarium study and experimental work on plantations are required before their proper value can be appreciated.

(1a)—Extract from Nature, Vol. 119, No. 2992, P. 362.

"The modern treatment of leprosy is based mainly upon improved technique in the administration of chaulmoogra and hydnocarpus oils or rather of the sodium salts or ethyl esters of their characteristic acids. In place of administration by the mouth, the drugs are now administered by intremuscular and intravenous injection, or by subcutaneous infiltration. Moreover, treatment is now continued over long periods of time. The bacillus of leprosy is a delicate organism, which can only secure a footing in an enfeebled host deprived of his natural powers of resistance by bad environment, scanty nutrition, or coincident disease. Residence under medical supervision in a well-organised leper colony suffices only to cure a small number of cases; the modern oil treatment has greatly increased the number of cures.

There are, however, still a considerable number of resistant cases, notably those of patients suffering from malaria, hookworm, or syphilis, who have been made vulnerable to leprosy infection. The difficulty is that the leper is

apt to react to well-known drugs quite differently from the non-leprotic patient. Thus, Dr. E. Muir, of the School of Tropical Medicine and Hygiene, Calcutta, states that it is often dangerous to administer the usual arsenical drugs, such as neo-salvarsan, to a syphilitic leper; so that it has become necessary to find a drug which combines the oil treatment referred to above with the antisyphilitic treatment for such cases. Such a drug has been prepared in the Wellcome Chemical Research Laboratories in London, under the direction of Dr. T. A. Henry, and has been tested since 1924 by Dr. Muir in India. The drug is a mercury derivative of meta-hydroxybenzaldehyde, rendered soluble in hydnocarpus or chaulmoogra oil, or in the ethyl esters made from these oils. It can therefore be injected in solution in these products, and the patient undergoes treatment for the two diseases at the same time. In the October issue of the *Indian Journal of Medical Research*, Dr. Muir gives the results of the treatment of thirty cases, all of which showed positive Wassermann reactions at the start. After treatment, sixteen became negative, two were doubtful, and only eight remained strongly positive, whilst all showed improvement so far as the concurrent leprosy was concerned. Not the least satisfactory feature of the new drug is its safety; in none of these cases did it give rise to undesirable symptoms."

### (2)—Hydnocarpus and Taraktogenos in the Federated Malay States.

On the publication of the previous article on this subject (*K.B.* 1926, p. 17) our attention was drawn by Mr. A. S. Haynes, now British Adviser, Kedah, to the experiments that are being conducted at the Serdang Plantation of the Agricultural Department, Federated Malay States. We are indebted to Mr. B. W. Elles, the present Secretary for Agriculture, Straits Settlements and Federated Malay States, who has kindly sent the following account of the work that is being carried out there on species yielding Chaulmoogra Oil.

### Notes on Hydnocarpus Species under Cultivation at the Experimental Station, Serdang, F.M.S.

B. Bunting and J. N. Milsum

In October, 1920, Dr. J. F. Rock, while on a visit to Kuala Lumpur, presented to the Department of Agriculture a parcel of seeds of *Hydnocarpus anthelmintica*, which he stated were obtained from trees growing in the streets of Bangkok (see U.S. Dep. Agric. Bull. No. 1057, p. 11). These seeds were planted at the Experimental Plantation, Kuala Lumpur, but were subsequently transferred to the Government Plantation at Serdang, which was then being opened up. From then onwards, several consignments of seeds of *Hydnocarpus spp.* have been received at Serdang and the object of these notes is to record the behaviour of the trees under cultivation, together with data collected during this period.

The planting programme at the Experimental Plantation, Serdang, provides for an area of 25 acres to be planted up with each of the following species:—*Hydnocarpus anthelmintica, H. Wightiana* and *Taraktogenos Kurzii.*

HYDNOCARPUS ANTHELMINTICA *Pierre.*

As previously stated, the seeds of this species were obtained from roadside trees at Bangkok, Siam. A number of seedlings were received at Serdang during February, 1922. Owing to suitable cleared land being unavailable, it was not found possible to plant out the young trees until May, 1923, when they averaged 2 feet high. The area selected for planting was on sloping land, facing west, in the arboretum. The soil is well drained, somewhat loose and overlying laterite. Forty-eight trees were planted at a distance of 30 feet by 30 feet triangular. This number was subsequently increased to 55, making an acre planted with this species.

The following table shows the rate of growth of the original forty-eight trees. It should be noted that, owing to the reason stated, considerable time was lost between germination of the seeds and final planting in the field.

TABLE I

*Rate of Growth of Hydnocarpus anthelmintica at Serdang.*

| Date | Average Height | Increase in Height over 12 months |
|---|---|---|
| June, 1923 ... | 2 feet 1 inch ... | —— |
| „ 1924 ... | 5 „ 6 „ ... | 3 feet 5 inches |
| „ 1925 ... | 10 „ 1 „ ... | 4 „ 7 „ |
| „ 1926 ... | 16 „ 6 „ ... | 6 „ 5 „ |

In addition to the trees in the arboretum, one of the Plantation roads was planted up with 50 young trees to form an avenue. The seedlings had been in the nursery beds for some time and when planted out early in June, 1923, averaged 7 feet in height. They were cut back to within 3 feet from the ground after planting. The distance between the trees in the rows is 33 feet and the space across the road from tree to tree is 32 feet; the planting arrangement being triangular. These trees are backward as compared with those in the arboretum, owing to the somewhat severe treatment they received at the outset. In October, 1926, the average height of the trees was 12 feet 6 inches. No sign of flowering has so far been observed.

Late in 1925 flower buds were observed on several of the largest trees in the arboretum. Only male flowers were noticed at first, but early in January, 1926, flowers of both sexes were noted, followed by the setting of a few fruits on three trees only. A number of the earliest fruits noticed failed to mature and dropped from the trees.

The flowers are unisexual and produced in short axillary cymes. They are pendulous, light green with a pink eye, very fragrant, and though small, attractive in outline. The female flower is larger than the male, the scales being broader. They appear in less abundance than the male flowers.

About 30 fruits have set on the three trees and of these twelve show signs of maturity. The first ripe fruit fell during October, 1926, and weighed 13½ ounces. It measured 3½ inches in diameter and about 3¾ inches in length. The fruit is globular in shape with a brownish tomentum in the young stage, hardening upon ripening to form a strong hard woody shell, rusty brown in colour. The fruit broke in falling and embedded in the creamlike pulp were 18 seeds. The seeds on being cleaned were found to be of somewhat irregular shape, almost an inch long and ¾ inch broad. The seed coat is hard and a dirty grayish brown in colour. These seeds have been planted and their power of germination will be carefully recorded.

Measurements of other fruit removed from the trees show dimensions as much as 4 inches in diameter and 4 inches in length. The fruits agree well in appearance with Dr. Rock's photograph published as Plate 11 in U.S. Dep. Agric. Bull. No. 1057, already referred to.

To summarize the position regarding the species, *H. anthelmintica*, it may be stated that 100 trees are established at the plantation and that the first fruit has ripened within 6 years from sowing the seed. It is to be noted that some delay occurred in planting out these trees in the field and should such trees be allowed to make uninterrupted growth from time of germination, it is possible that they would reach the producing stage much earlier. The tree appears to grow well under local conditions, as would be expected of a tropical rain forest species, and has not yet shown signs of being attacked by insect pests or fungoid diseases.

HYDNOCARPUS WIGHTIANA *Blume.*

The source of supply of seeds of this tree was the Bombay Presidency.

Mr. M.S. Tuggerse, Divisional Forest Officer, Honavar, Kanara, who sent the seed, supplied the following notes under cover of his letter of the 13th September, 1924.

"This is a large-sized ever-green tree growing in the rain tract of the West Coast of Kanara (Bombay), where the rainfall is from 120 to 200 inches per annum, chiefly falling between June and October. Trees of 10 to 12 feet girth with a crown spreading over 400 sq. yards of area are not uncommon. Isolated trees growing in the open often attain this size, though the stems get fluted. Trees grown mixed in the forests usually attain a great height, often from 60 feet to 80 feet, with a thin clean bole, but under such conditions the development of the crown is not great and the production of seed is naturally very limited.

"Where the object is the production of a maximum quantity of fruit per tree, planting should be done well apart. I recommend 40 trees to the acre, i.e., 33 feet by 33 feet. But the clearing of the original forest (where such has to be done for concentrated planting of a given species) would cost much and a long period would elapse before the trees attain their maximum crown development. It would, therefore, be best to plant 16½ feet by 16½ feet, i.e., 160 to the acre, in squares at the beginning, and to thin out the intervening trees later on, and to grow catch crops in the meantime.

"Fresh seed may be sown direct 'in situ.' For this, dig large holes 3 feet by 3 feet, refill the soil and sow 2 or 3 seeds. If more than one seed germinates pull out the rest but keep one good plant after they have grown about a foot high. Where direct sowing is not possible, raise the plants in nursery and plant out when they are 6 to 12 ins. high. For successful results in transplanting, basket or pot-planting is good. Seed germinates in about fifteen days after sowing.

"In Kanara the tree is found on deep alluvial deposits by the side of perennial fresh water rivulets (nallas). They also grow on mooram soils and laterite, from the sea level to 1,800 feet elevation.

"To encourage the trees to grow a large crown it is best to undertake thumb-nail pruning when the plant attains a height of about 6 feet to 8 feet; later on, training of branches must be done patiently and perseveringly. This is a markedly sun-loving tree, i.e., light demander, as most of the trees in the tropics are. For the production of the fruit, sunlight is necessary, also a spreading crown.

"It appears that the tree lives to a great age under favourable conditions of soil, but trees bear fewer and fewer fruits as they grow older. In order that an old tree may be rejuvenated, lop out all smaller branches and the tree will begin to bear in the second year after pollarding. Trees that attain a maximum development may yield up to 1 cwt, of clean seed."

The first consignment of 2,000 seeds was received in October, 1924, but though given careful treatment they failed to germinate. The seeds were dug up and examined in March of the following year and all were found to be decayed. Two further consignments of about 2,000 seeds each were received subsequently from Mr. M.S. Tuggerse, during July, 1925. In forwarding these seeds Mr. Tuggerse stated that they were collected in June, 1925, under his personal supervision. The seeds weighed 12 lbs. on arrival, giving an average of about 24 seeds to the ounce.

In addition to forwarding the seeds and notes regarding the cultivation of this tree, Mr. Tuggerse kindly forwarded specimens of mature fruits and a photograph of one of the trees from which the fruits had been collected. The fruits were found to contain an average of 20 seeds each.

The two consignments were planted on the 20th July, 1925, in several ways and gave an average germination capacity of 52 per cent. Germination commenced a month after sowing and continued for seven weeks, when the balance of seed was found to be unsound.

The following data regarding the germination of the two consignments is recorded:—

TABLE II.

| Method of Sowing. | Consignment 1. | Consignment 2. |
|---|---|---|
| In nursery beds under shade - | 76 per cent ... | 72 per cent ... |
| In open nursery beds - | 60 „ „ ... | 49 „ „ ... |

A certain number of seeds were planted in boxes of soil under shade. Only 28 per cent. germination was recorded, but this is thought to be due to allowing the soil in the boxes to become too dry.

It appears, therefore, that the seeds should be given moist conditions under shade to secure maximum germination. The seeds from the whole fruits were sown separately under shade and gave a germination capacity of 97 per cent. in eight weeks from sowing, which is considerably in excess of that from the seeds separated from the fruits.

The seedlings raised in boxes were subsequently transplanted into small bamboo baskets and this method of planting was found to be more satisfactory as compared with transplanting the young trees direct from nursery beds into the field, even though a good ball of soil was allowed to adhere to the roots.

The area selected for planting this species was similar to that in the arboretum already described. An experimental planting of kapok (*Eriodendron anfractuosum*) had been undertaken on the land and it was necessary to devise a system of interplanting. A commencement was made to plant up the area at the end of November, 1925, at a planting distance of 40 by 20 feet, rectangular, requiring 54 plants per acre, alternating lines of *H. Wightiana* being planted between the kapok. Approximately 25 acres were planted in this way, but as indicated above a number of the young plants died off during dry weather. These were subsequently supplied and the whole area, excepting some ravines, is now fully planted and the trees are growing well. The average height of these trees in October, 1926, was 2 feet 6 inches.

As in the case of *H. anthelmintica*, this species is being tested as a road-side tree and 50 trees were planted during May, 1926, on either side of one of the Plantation roads. The trees are planted in triangular fashion, the distance between the trees in the rows being 33 feet, the rows being 27 feet apart. The young trees are making good growth and in October, 1926, averaged 2 feet in height.

Though this speices is not so far advanced on the Plantation as the previous one, a comparatively large area has been planted up and the trees are making rapid growth Both species appear amenable to plantation conditions and are readily raised from seed.

TARAKTOGENOS KURZII *King.*

Six young trees labelled *Taraktogenos Kurzii* were received from the Botanic Gardens, Singapore, during August, 1923. Mr. R. E. Holttum in sending these plants stated that the seeds from which the trees were raised were obtained in the Upper Chindwin District, Upper Burma, by Dr. Rock and were received at Singapore in February, 1921.

The trees were planted out in the arboretum on rather low-lying land, during the latter part of May, 1924. The young trees then averaged 1 foot 10 inches in height. The heights of the trees have been recorded yearly and their growth is shown to be rather slow. In June, 1926, the height of the six trees varied from 2 feet 6 in. to 7 feet 9 in., averaging 5 feet. Two trees, however, have made comparatively good growth and it appears as if the soil conditions are not altogether suitable. So far no signs of flowering have been observed.

In June, 1926, a small parcel containing 32 seeds of this species was received from the Conservator of Forests, Utilization Circle, Burma. When forwarding the seeds the Conservator of Forests stated that they had been obtained by the Divisional Forest Officer, Thaunggin Division. The

seeds were sown on the 26th June, 1926, and germination commenced a month later, continuing for three weeks. Fourteen seeds germinated in all, but actually only ten young plants were raised owing to damping off. These have been established in bamboo baskets and in October, 1926 averaged 7 inches in height, showing a pair of true leaves in addition to the cotyledons. The seedlings agree well in appearance with the illustration of the species on Plate XVI, in Bull. 1057 of the U.S.A. Department of Agriculture.

It will be seen that so far no very great progress has been made with this important tree. There appears, however, probability of obtaining further supplies of seed, and when these are forthcoming, it is anticipated that there should be no difficulty in planting up the proposed area according to the original planting programme.

The writers are indebted to Messrs. E. A. Curtler and J. Lambourne, Assistant Agriculturists at the Experimental Plantation, Serdang, who have jointly been in charge of the experimental records connected with the cultivation of the various species mentioned in this article.

## (2A)—Additional Notes on Hydnocarpus and Taraktogenos at the Government Plantation, Serdang.

Since the compilation of the Notes on Hydnocarpus species under cultivation at the Experimental Plantation, Serdang, F.M.S. published in *Kew Bulletin*, No. 2, 1927, the following additional information has become available:—

*Hydnocarpus anthelmintica.*—The trees in the arboretum and elsewhere on the Plantation have continued to make good growth. As already recorded, the original forty-eight trees in the arboretum produced mature fruit in October, 1926. In all, a total of twenty-seven fruits have matured and fallen from three of these trees. At the time of writing (April, 1927) eleven trees are bearing fruit in various stages of growth, of which four are also flowering. In addition, twelve other trees are flowering. The flowers are produced in small numbers, usually on the upper portions of the main branches. Of the fruit that have ripened, 60 per cent. matured during the present month. The fruits in general, conform with the data previously recorded. One large fruit was found to contain thirty-four seeds; the largest number so far counted.

The fruits on falling are collected and the seeds extracted and cleaned. They are then planted, under shade, in soil containing a fair amount of humus. Germination commences, on the average, during the seventh week from planting and

already a fair number of seedlings have been established in bamboo baskets and should be ready for planting in the field during the latter part of the year.

In February, 1927, a parcel of seeds was received from Siam through Dr. W. H. Hart, Acting Senior Medical Officer, Selangor, for planting at the Experimental Plantation, Serdang. Under cover of his letter, the Senior Medical Officer forwarded an interesting note on the cultivation and yield of this tree, by Dr. A. F. G. Kerr, Director of Botanical Section, Ministry of Commerce, Bangkok, Siam, details of which are given below:—

### Note on Cultivation and Yield of Hydnocarpus Anthelmintica in Siam.

"In its natural state *Hydnocarpus anthelmintica* is usually found on a sandy loam and near water, either on the banks of rivers or on the edges of marshes. Occasionally it grows on mountains at an altitude of about 800-1,000 metres. It is an evergreen tree itself and its associates are mostly evergreens. The seedlings come up in fairly dense shade, on ground that has a good top layer of leaf mould. The time that will elapse from the planting of the seeds to the germination is about 6 to 8 weeks".

"In cultivation it can be grown with only partial shade and the seedlings are able to stand a fair amount of sun, but they should have some shade. They do well in a mixture of clay, sand, and leaf mould, and should have plenty of drainage. During dry weather they should be watered every other day. The tree is often cultivated in the stiff Bangkok clay and is even planted along road-sides but does not do so well as under its natural conditions. Growing naturally the trees along the river banks are subjected to occasional floodings during the rains, but for 6 to 7 months of the year they are well above water level. Groves of pure stands of wild trees are frequent, and in such situations the trees are about 12-20 metres apart."

"There is no exact information as to the age when the tree begins to bear, but, judging from the rate of growth of seedlings and size of bearing trees, it is probably not less than 8-10 years. In the forest trees are not found bearing till they are of considerable size, with a trunk of at least 50 cm. in circumference. The trees probably go on yielding fruit for many years, old trees, growing naturally, have been found with a trunk circumference of over 4 metres. The yield is rather irregular, depending a great deal on the rainfall, if the latter is deficient the crop is poor. If conditions are good trees will fruit every year."

"In a fair season an average sized tree, with a trunk measurement of about 1.20 metres, will yield some 200 fruit. The number of seeds in each fruit varies considerably, on a

good tree from 25 to 115 in each, but the average for healthy trees, may be taken as 65: that is a total of 13,000 seeds for the whole tree. Mr. Marcan, Director of the Government Laboratory, Bangkok, estimates the average weight of 100 dry unhusked seeds to be 136.2 grams and that 100 kilograms of dry, unhusked seeds yield 14 litres of ethyl esters. The yield of one average tree should be, therefore, calculating from the above data, about 2½ litres of ethyl esters annually.

*Note on Climate.*—The region where *Hydnocarpus anthelmintica* most commonly grows has an annual rainfall of about 1,270 mm. (50 inches), distributed chiefly over the months May to October. Long dry spells are usual during the other months. The mean temperature is about 27 C. (81 F.) with extremes of about 40 C. (104 F.) maximum and 14 C. (57 F.) minimum."

The seeds weighed 11 lbs. 2 ozs. on arrival and numbered 3,620. They were planted on the 15th February in prepared soil in boxes under shade but so far no germination has occurred. A number of seeds have been examined and found to be rotten. As it appears doubtful whether this consignment will be a success a further supply of fresh seed is being obtained.

*Hydnocarpus Wightiana.*—The young trees in the 25 acre block and in the avenue have made continued rapid growth. A further batch of trees of this species was planted in the arboretum at the end of 1926.

*Taraktogenos Kurzii.*—In addition to the six trees established in the arboretum, a further nine seedlings were planted out towards the end of 1926.

## Explanation of Plates.*

Plate I. *Hydnocarpus anthelmintica.*—Trees three and a half years from planting in the field.

Plate II. *Hydnocarpus anthelmintica.*—Fruit matured at Serdang. Actual size three and a half inches diameter.

Plate III. *Hydnocarpus Wightiana.*—Seedlings in baskets ready for planting in the field.

Plate IV. *Hydnocarpus Wightiana.*—Young tree one year from planting in the field. Scale=1 ft.

Plate V. (1) *Hydnocarpus anthelmintica.*—Drawing of fruit matured at Serdang.

(2) *Hydnocarpus Wightiana.*—Drawing of fruit received from Kanara, Bombay (½ nat size).

Plate VI. *Hydnocarpus anthelmintica.*—(1) Seed. (2) Seed germinating. (3) Seedling one week old showing cotyledons. (4) Seedling four months old. (½ nat size).

* Drawings and photographs by Mr. J. N Milsum.

PLATE I

PLATE II

PLATE III

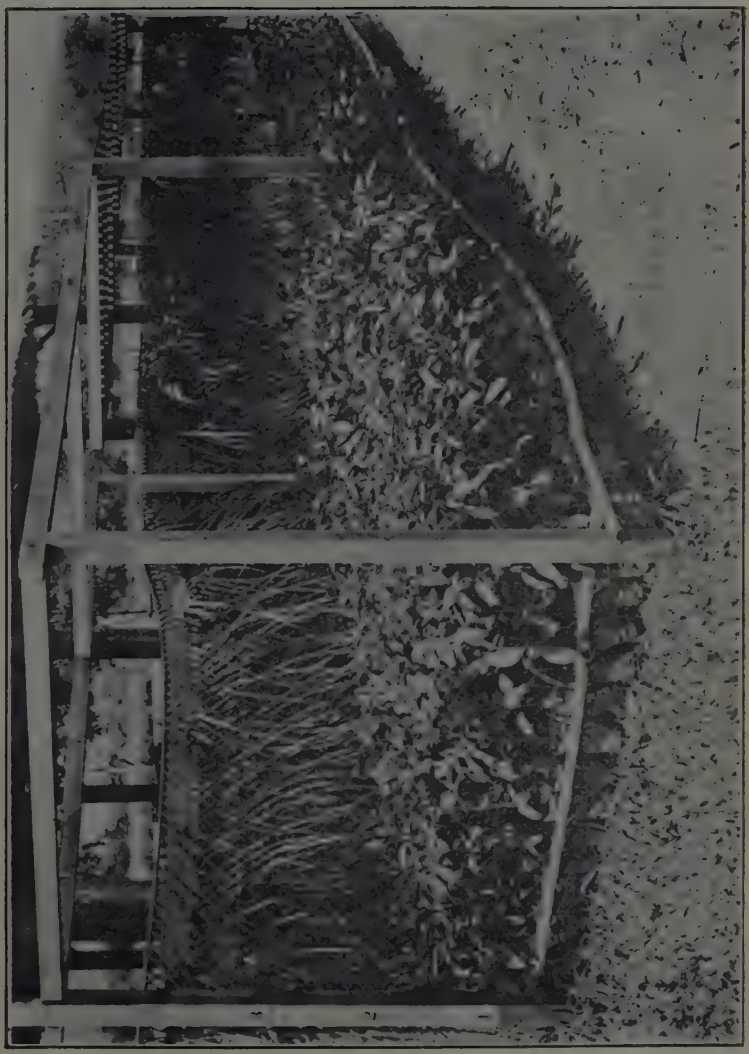
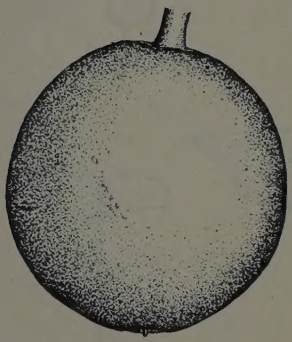
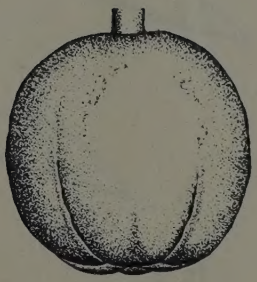


PLATE IV

PLATE V.



1



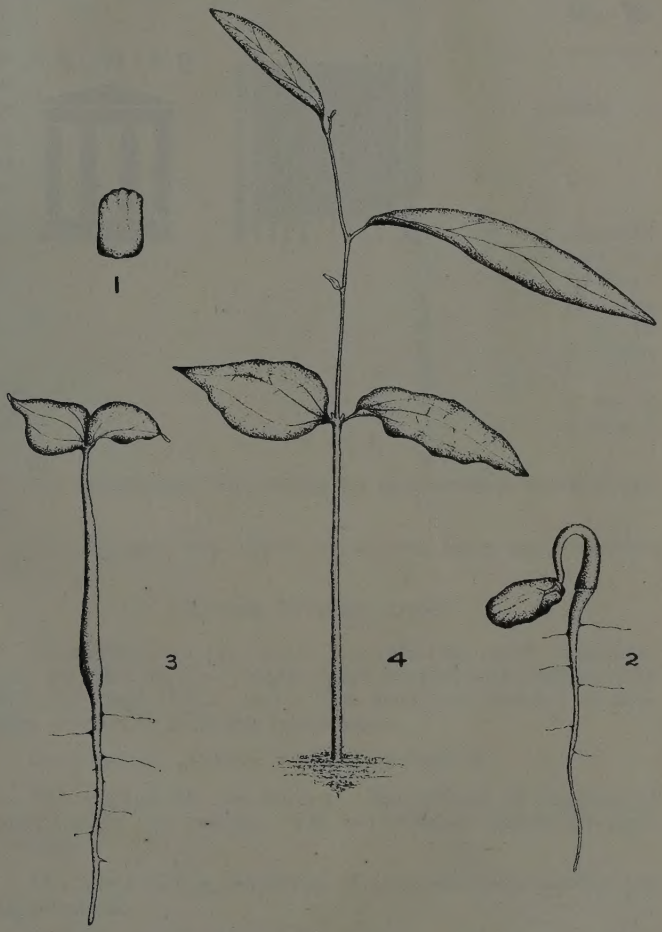
2

1. *Hydnocarpus anthelmintica.* Fruit matured at Serdang.

2. *Hydnocarpus Wightiana.* Drawing of a fruit received from Kanara, Bombay.

PLATE VI.

HYDNOCARPUS ANTHELMINTICA.




1. Seed. 2. Seed germinating. 3. Seedling 1 week old showing cotyledons. 4. Seedling 4 months old.

Drawn from material obtained at the Experimental Plantation, Serdang.